M. ILIN

TURNING NIGHT INTO DAY

The Story of Lighting

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BY M. ILIN

MEN AND MOUNTAINS
Man's Conquest Over Nature

100,000 WHYS
A Trip Around the Room

BLACK ON WHITE
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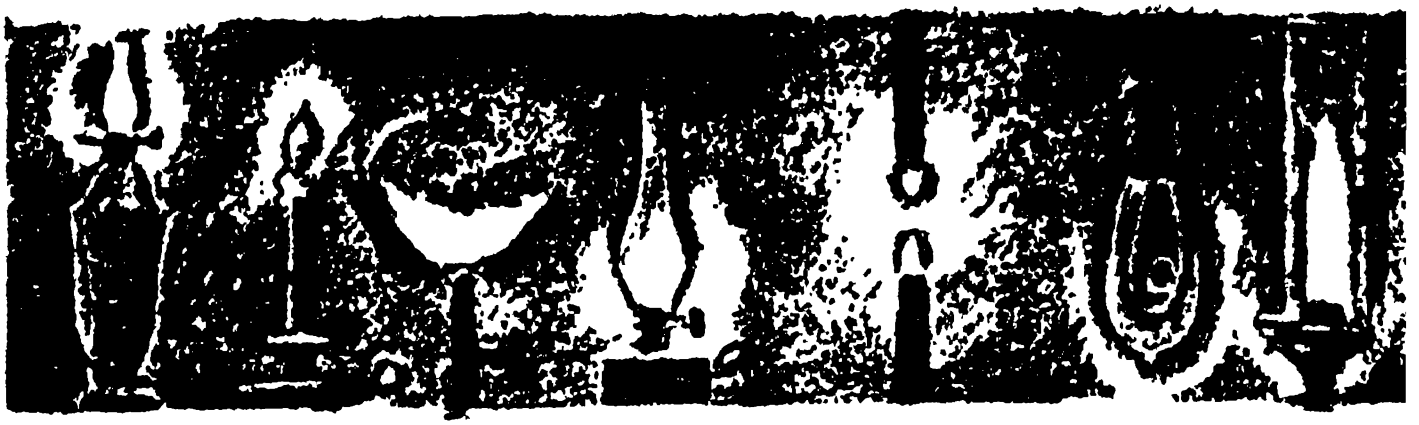
WHAT TIME IS IT?
The Story of Clocks

TURNING NIGHT INTO DAY
The Story of Lighting



TURNING NIGHT INTO DAY

The Story of Lighting

BY

M. ILIN

WITH THE ORIGINAL
RUSSIAN ILLUSTRATIONS BY
N. LAPSHIN

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STREETS WITHOUT LIGHTS

Thousands of Edisons

WHO invented the electric lamp?

The usual answer to this question is: "Edison, a famous American scientist."

But this is not true. Edison was only one of the many inventors to whose work we owe the artificial sun which nowadays lights up our streets and houses.

There was a time when there was not a single street lamp of any description in any city street. People had to sit at home in the evening with only the dim light of a tallow candle or a smoking oil lamp.

This ancient oil lamp, shaped something like a teapot, hasn't the slightest resemblance to our electric light bulbs. Nevertheless, the modern

electric lamp descends in a direct line from this queer looking old teapot, with many changes along the way—some small and unimportant-looking, but all significant.

Thousands of inventors throughout thousands of years have worked to give us a brighter and better lamp.

A Bonfire in the Living-Room

Compared with the lamps which preceded it, this clumsy oil lamp was an elegant and ingenious invention.

There were times when there was no such thing in existence as a lamp of any kind. Fifteen hundred years ago, on the spot where Paris stands to-day, stood a dirty little town called Lutetia. All the houses in Lutetia were tiny wooden huts with straw-thatched or tiled roofs. If you had

A Bonfire in the Living-Room

gone into one of these little houses you would have seen a fire burning right in the centre of its one room. In spite of a hole in the roof the room was full of smoke which would have made your eyes smart and filled up your lungs so you could hardly breathe.

This fire was their lamp, stove and fireplace. It must have been a very dangerous thing to light a bonfire inside a wooden house and you can easily imagine how many times their houses must have caught fire and burned up.

People had a terrible fear of fire in those days, and no wonder. They thought fire was some kind of awful, devouring enemy, always lurking about looking for a chance to fall on the house and destroy it.

It was only about seven hundred years ago that stoves with chimneys first appeared in Europe. It was even later here in Russia where until very

recently peasants in some places still lived in "black", that is chimneyless, huts heated by stoves without any chimneys whatsoever.

When they started a fire in one of these stoves they had to leave the outside door open to let the smoke out. And to keep the children from being frozen to death by the cold air that came in or choked by the smoke in the room, they would put them to bed even in the middle of the day, and cover them up head and all with their big heavy sheepskin coats.

A Piece of Kindling Instead of a Bonfire

But someone had the brilliant idea that it wasn't necessary to build a whole bonfire to light the house; that all one needed for this was one small stick of kindling wood.

The fire filled the house with smoke and also used up too much wood. So, when they wanted light only, people began to burn one stick at a time instead of a whole pile of wood. They would split up a straight-grained log without knots into slender pieces of kindling wood about a yard long, and light them at one end. That is, instead of a bonfire they used a " kindle-light ".

This kindle-light was a wonderful invention for its time. It continued in use for more than a thousand years. Not so very long ago it was still used in some out-of-the-way Russian villages.

But it was hard to keep these pieces of kindling burning. If you have ever tried to start the fire in a samovar with a piece of burning kindling you know how it has to be held at an angle, burning end down. Otherwise it will go out.

Why ? Because the flame always goes upwards along the wood. This is because the air near the

burning wood is heated and, as hot air is lighter than cold, this air goes upwards and carries the flame along with it.

So this light had to be held at an angle, pointing downwards, with the flame at the bottom, otherwise it would go out. Now, it would be too tiresome to have someone stand and hold it in this position all the time. So people thought out a very simple device. They made a holder for the light by setting a straight stick upright in a stand, with an iron clamp on the top to hold the light in the right position.

This wasn't so bad a light as you might think. In fact this kindle-light gave a very satisfactory light. But what a lot of smoke and soot! And what a lot of work and bother with it! They had to keep an iron plate on the floor under it so it wouldn't set the house on fire, and had to keep putting in new sticks every little while. It was

The Kindle-Light

usually the job of one of the children to look after the kindle-light while the grown-ups worked.

Torchlight

It wasn't always easy to find the right kind of wood for these kindle-lights. But people weren't daunted by this difficulty. Someone noticed that kindle-lights made of pitchy wood burned much better than any others; that is, that it wasn't the wood so much as the pitch that was doing the burning. They found that any kind of wood, smeared with this pitch, would burn as well as or better than those made of the pitchy wood itself. This was the origin of the torch.

Torches gave a very bright light. Whole rooms could be lighted up with them when great feasts were held. There is a story of how, in the hall of

Gaston de Fois, twenty servants, holding torches, stood about the table during supper. In royal palaces there were often silver statues to hold the torches instead of living servants.

Torches, and kindle-lights too, may still be seen occasionally. In some places the fire brigade goes roaring through the streets with flaming torches, recalling those days of long ago.

The First Lamp

When they couldn't get pitch, people used to make torches by soaking the wood in some other inflammable material, such as grease or tallow. Besides giving a better light, the torch had another advantage over the kindle-light—it burned longer. It is easy to see why : there was much more pitch in a torch. This suggested the idea that the wood

Servants, Holding Torches, Stood about the Table

might be discarded entirely and only the pitch or tallow used. So they began putting the pitch or tallow into a cup of clay or stone and setting fire to it.

This was the first lamp. It would burn for several hours at a time, instead of only half an hour like a kindle-light.

Now, the next problem was to get rid of the smoke and soot. For this primitive lamp smoked horribly.

Lamps and Smokestacks

Why do lamps smoke?

For the same reason that the smokestacks of a factory smoke. If you see thick black smoke coming out of the smokestacks of a factory that burns wood you may be sure that that factory

either has poor furnaces or that the fireman doesn't understand his business. Only a part of the wood is being consumed in the furnace, the rest of it is going off up the chimney. Of course it is not going up in the form of wood, but as soot—that is, tiny particles of carbon which have not been burned up.

The trouble is you can't have fire without air. To get the wood to burn up entirely the fireman has to regulate the amount of air entering the furnace by opening or closing the damper in the chimney. If there is too little air in the furnace part of the wood will not be burned up, but will go off up the chimney in the form of soot. If there is too much air it is bad, too, because this will cool off the furnace.

Smoke, then, is soot—that is, tiny particles of carbon. But how does this carbon get into the

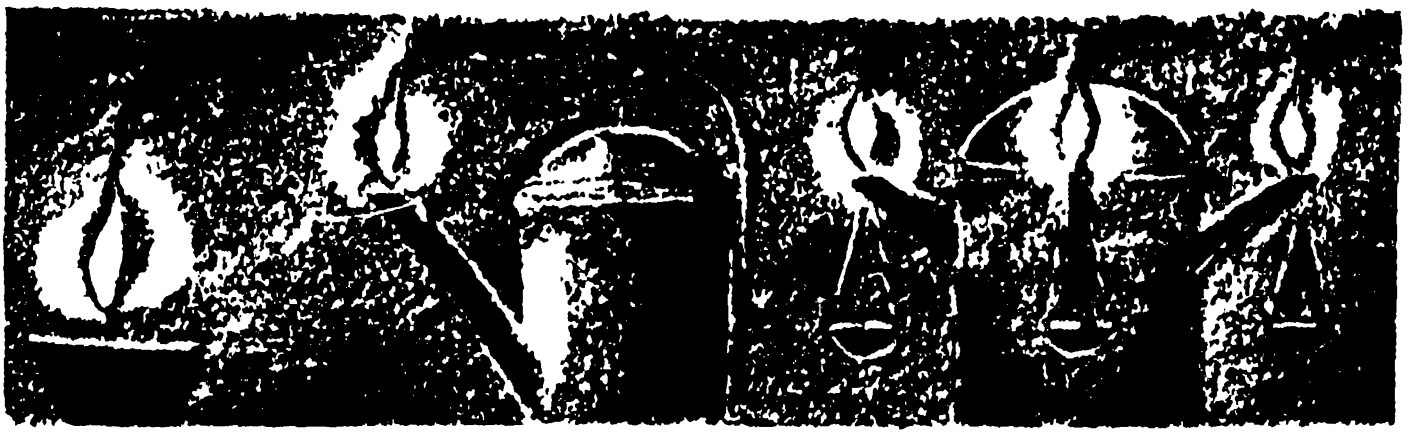
lamp flame? From the paraffin or oil or pitch, or whatever we burn in the lamp. It's true we can't see any carbon in paraffin or pitch. But can you see sugar in your tea or cottage cheese in your milk?

If a paraffin lamp is properly trimmed it will not smoke. All the carbon is burned up in the flame. But the lamps of olden times, unlike ours, smoked all the time. They didn't have enough air, you see, so the little particles of carbon couldn't all be consumed in the flame. The reason they didn't have enough air was that they burned too much grease or oil at a time. Something had to be done so that only a little oil would be fed to the flame at a time. And someone thought of the idea of using a wick.

The wick was made of hundreds of threads, each thread a little tube through which the oil was fed little by little to the flame, just as ink soaks up

into blotting paper when you hold it in the ink-well.

The very first lamps looked like our little night lamps or the lamps which burn in churches before



The Teapot-lamp

the altars. They were simply little bowls with a wick stuck in tallow or oil. Even in those days they had begun to burn vegetable oil in place of tallow in the little church lamps. This vegetable oil was first brought from the Orient by Arab merchants. Europeans hadn't yet learned how to make it. Later, when the people in European

The Teapot-lamp with Chains

countries had learned how to make this vegetable oil, they stopped using tallow in their lamps.

Now the wick in the lamp gradually burned down. It had to be pulled out continually. In order to do this more easily a specially shaped lamp was devised, with a spout on the bowl, through which the wick was inserted into the oil. It really was made exactly like a teapot. Sometimes lamps had more than one spout—very big ones, as many as twenty.

These lamps were suspended from the ceiling by chains, with a smaller shallow bowl hung under them to keep the oil from dripping down on the table or floor beneath. The wicks were made of hemp and pedlars used to go about the streets hawking them and calling out :

" Buy fresh wicks for your spout
So your lamp won't go out."

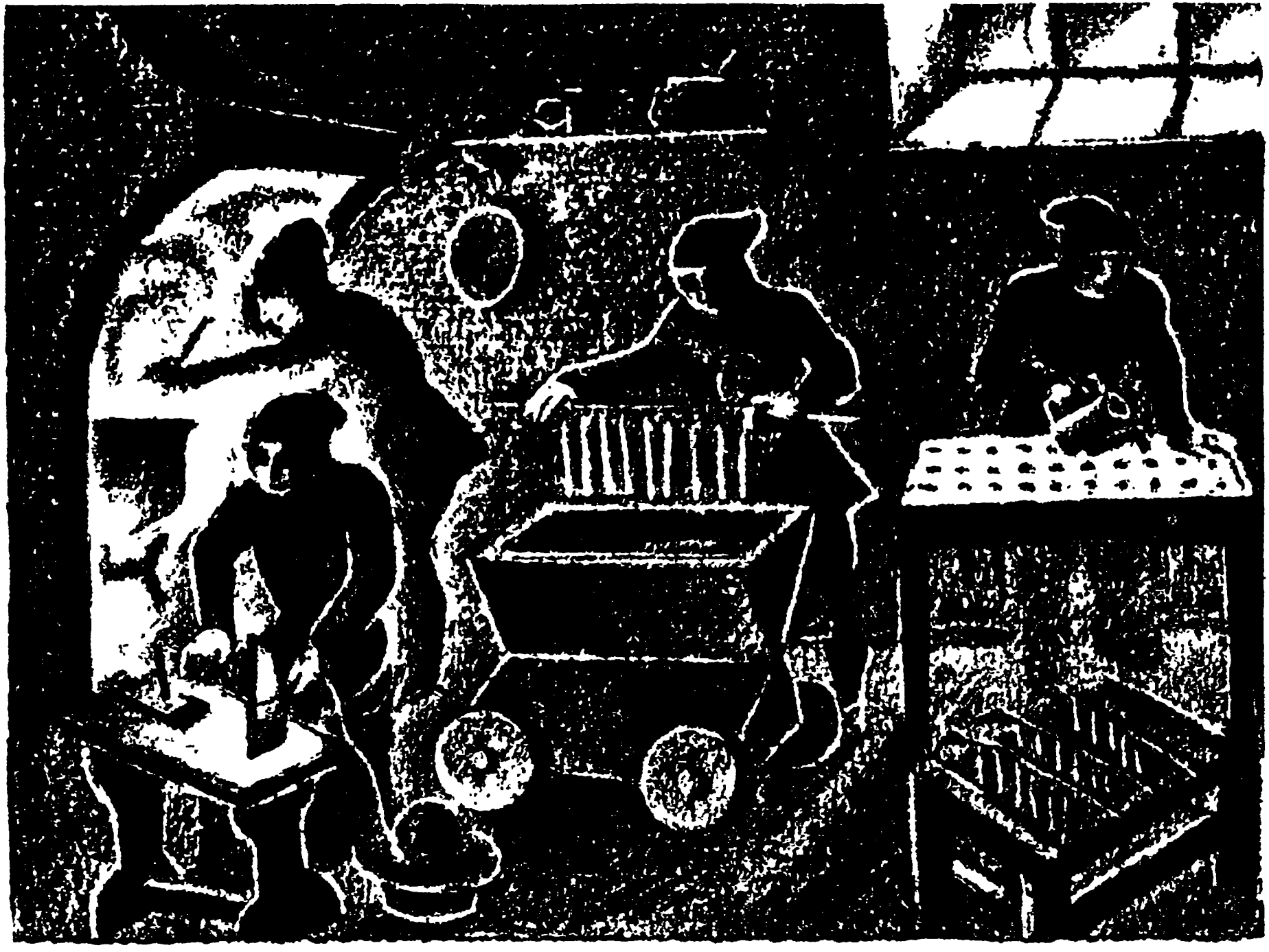
A Lamp without a Bowl

The indispensable things in a lamp are the oil and the wick—the bowl isn't so important.

Why, how in the world could we get along without the bowl?

That's very simple. All you have to do is to dip the wick into hot melted tallow and then take it out again. The whole wick will be covered with a layer of tallow and when it cools you have a candle.

That's the way they made candles in olden times. They would tie several dozen wicks to a rod and let them all down at once into a kettle of melted tallow. They dipped them in several times so there would be a thick coating of tallow on the wicks. Such candles were called "dips". Most housekeepers made their own candles instead of buying them.



Making Candle-dips

Later they learned to pour candles in special moulds made of tin or pewter. The moulded candles were, of course, much better looking than the dipped ones. They came out smooth and even.

Candles were made of wax, too, as well as of tallow. But they were much more expensive, so they were used only in churches. Even kings could permit themselves this extravagance only on festive occasions. Sometimes at big celebrations the royal courts would be lighted up with hundreds and hundreds of wax candles.

Even tallow candles weren't so cheap. As recently as a hundred years ago whole families would spend their evenings by the light of a single candle. When they had guests they would light up two or three candles and everyone thought this was a very brilliant illumination.

How comical it would seem to us to have a

dance by the light of three tallow candles! We think even a 60-candle power light weak. We shouldn't be satisfied with stearine candles even, yet our ancestors had only tallow ones, which weren't nearly so good as those of stearine.

A tallow candle always smokes. Worse than that, it has to be continually snuffed. If you don't snuff it the candle gets covered with drippings. The reason is that the tip end of the wick, which extends out beyond the flame, doesn't burn up entirely and gets longer and longer. This makes the flame bigger, just as in a paraffin lamp when you turn up the wick. The big flame melts more tallow than is necessary and it runs down the sides of the candle.

So the wick had to be kept trimmed with a pair of special scissors called snuffers. These snuffers were usually kept on a little tray near the candle.

Hundreds of Wax Candles

It was considered very bad manners to pinch off the end of the wick with one's fingers. And the charred end of the candlewick must be thrown on the floor and stepped on so that "no evil smell should offend our nostrils".

In the stearine candles of to-day the wicks are so made that they don't have to be snuffed. This is because the hottest part of the flame is not inside where it is difficult for the air to penetrate, but on the outside, where there is more air.

You can easily prove this for yourself. Take a sheet of paper and hold it for an instant over the candle flame; a little circle will be burned in the paper; this shows that the flame is not so hot in the centre as on the outside. In a tallow candle the wick is in the centre of the flame all the time, so it doesn't burn well and gets a charred end.

In a stearine candle the wick is not twisted as in a tallow candle. It is braided. This tightly

braided wick keeps unwinding at the end and these ends stick out into the hottest part of the flame and are consumed as the candle burns down.

A Candle Clock

In olden times when a man was asked what time it was he used to look at a candle instead of at a clock. And this was not because he was absent-minded, either, but because in those days candles were used not only to give light but also to measure time.

They say that in the chapel of Charles the Fifth a big candle was kept burning night and day. This candle was divided into twenty-four parts by black lines, denoting the hours of the day. Special servants were detailed to tell the king from time to time how far down the candle had burned.

Snuffers

This candle was no small one, of course. It was made just long enough to burn exactly twenty-four hours.

Centuries of Darkness

After the invention of torches, oil lamps and candles people were satisfied with this poor light for a long time. They were really wretchedly poor lights. Not only that, they also smoked and sooted and sputtered and guttered. It was enough to give anyone who wasn't used to it a headache.

Portable lanterns had chimneys made of metal sheets with holes punched in them, like a sieve. Only a small part of the light could get out through these holes.

No one had ever thought of such a thing as street lamps. Except on moonlight nights it was pitch

dark in city streets at night. And street lamps were needed then even more than now, for the streets were not paved and the ground was rough and muddy and covered with filth.

Gutters ran down the middle of the streets to carry off the sewage. People walking along the street tried to keep close to the houses. But this was almost as bad, for at any moment someone might empty a pail of slops out of an upstairs window right down on their heads as they passed.

To insure themselves against such an unhappy fate, people who could afford it used to have servants go ahead of them with lighted torches to light up the way.

"Someone might empty a pail of slops right down on their heads"

THE FIRST STREET LIGHTS

THE FIRST STREET LIGHTS

Night and Day

IN olden times people, both those who lived in cities and those who lived in the country, began their day with the dawn and ended it when the sun set. There were no factories. There was no such thing as night work. All manufactured articles were produced in artisans' workshops. Everybody went early to bed and everybody got up early in the morning. There was no special need for lamps or street lights.

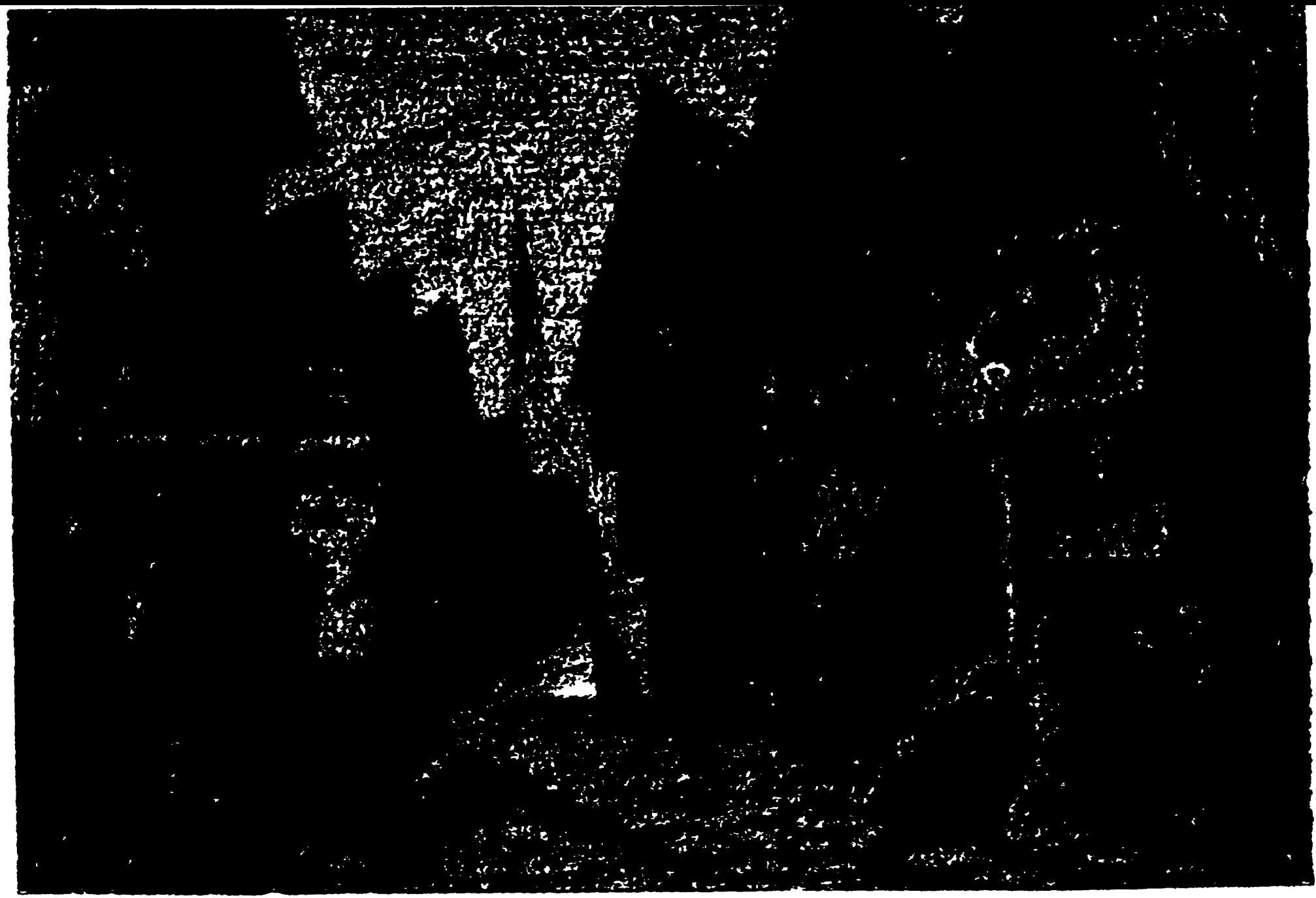
However, as industry developed, when large workshops began to appear, and a little later, factories, city life became an entirely different thing. The factory brought in the long working day and the night shift. Factory whistles shrieked long before daybreak, calling the workers to their

jobs. Cities began to waken up earlier and go to bed later. Life in them ceased to be measured by the sun. Days grew longer, nights shorter. This made lamps and street lights a necessity. Light, bright and inexpensive light, was urgently needed.

Then began the work of inventors, which led eventually to gas and electricity. This, of course, did not happen all at once, any more than the old medieval town changed all at once into a modern manufacturing town. Our electric light has a long line of ancestors.

The Mysterious Disappearance of the Candle Flame

At first the inventors tried to improve the oil lamps. Now the first thing they had to know in order to make a good oil lamp was what happens to



Streets of Olden Times

oil when it burns. They had to find out exactly what combustion is. It was only when this problem had finally been solved that good lamps began to appear.

If we put a burning candle into a jar and close the jar, the candle will burn all right for a while. But in a few seconds the flame will begin to die down and finally it will go out. If we take the candle out, relight it and put it back into the jar it will go out immediately this time. Now, there is still air in the jar, but there is something lacking in it, something which is necessary to produce a flame.

This " something " is a gas which is one of the component parts of air. It is called oxygen. When the candle burns, oxygen is used up and disappears. But this still doesn't explain exactly what combustion is. We see that the candle has gone out and furthermore that something has

happened to the oxygen. What is the secret of this mysterious disappearance?

The explanation is that it only seems to us that the candle flame has gone out.

If you put a drinking glass over a candle flame it will be coated inside with soot, and drops of water will form in it. This shows that water is given off in the process of combustion. But besides water, which we can see, another substance is given off, an invisible gas, carbon dioxide. When we put the burning candle into the jar, a layer of this carbon dioxide collected at the bottom of the jar and the candle could not burn in this any more than it could in water.

This carbon dioxide can be poured out of the jar like a liquid. If we then put the lighted candle back unto the jar it will not go out at once. It will burn until another layer of carbon dioxide has collected.

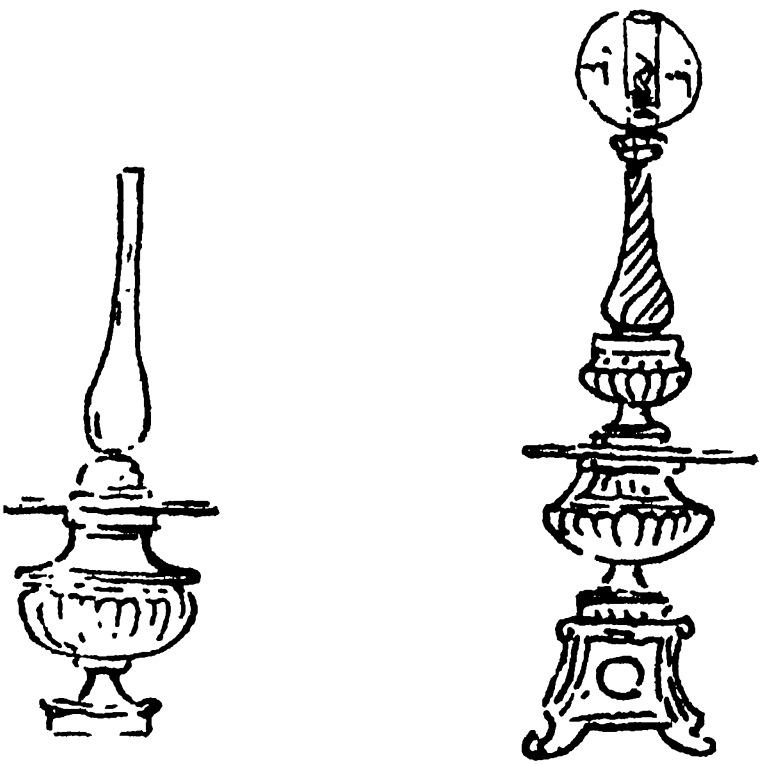
That is, when a candle burns, neither the candle nor the oxygen in the air are destroyed. They are merely changed into carbon dioxide and water vapour.

Formerly this was not known. A little more than four centuries ago there was only one man living who had figured out what combustion really was. This was the Italian artist, scientist and engineer —Leonardo da Vinci.

A Lamp with a Samovar Chimney

Leonardo da Vinci even in those early days understood that soot was due to an insufficient supply of air. He came to the conclusion, too, that to supply sufficient air there must be some kind of draught like that in a stove, that a chimney must be put over the flame. Then the heated air

would go off up the chimney, carrying with it the carbon dioxide and water vapour, and fresh air would come in from below with plenty of oxygen in it.



So the lamp-chimney was invented. At first it was made of tin, like the chimney of a samovar, instead of glass. And it wasn't put right on the lamp bowl, as glass chimneys are, but was placed up above the flame. It was some two hundred years later that a French apothecary named

A Lamp with Spring

Quinquet had the bright idea of substituting a transparent glass chimney for the original one made of tin which would not let the light out. But even he didn't realize that since the chimney was transparent it could be put lower down, right on the burner. It was not until thirty-three years later that Argand, a Swiss, realized this fact, which you would think anyone would have seen at a glance.

Complicated Lamps

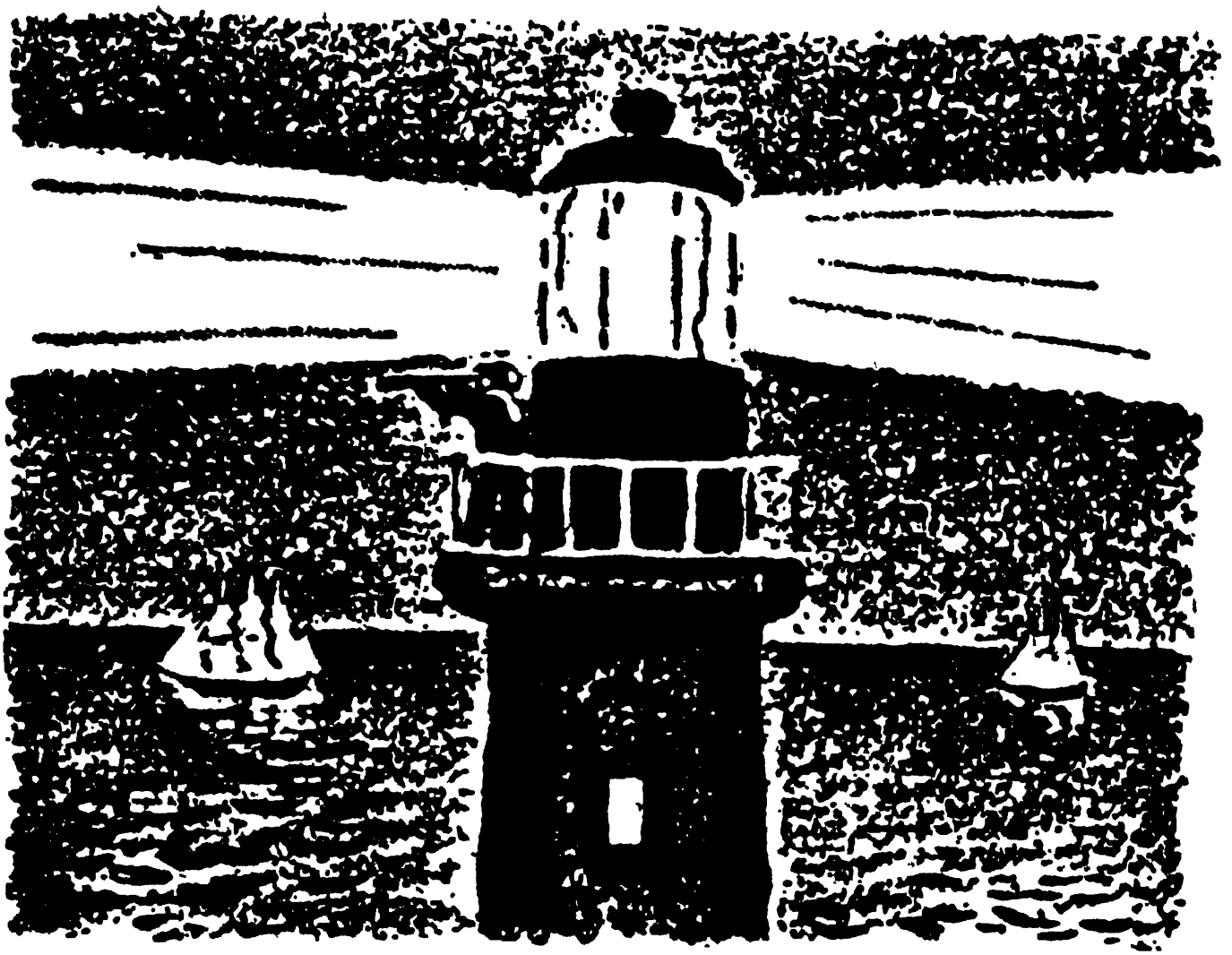
So, little by little, the lamp was made up, part at a time. At first only the bowl for holding the oil, then the wick, and finally the glass chimney. But even this lamp with the glass chimney didn't burn any too well. It didn't give any more light than a candle. The oil didn't run up the wick very well; not so well as our paraffin. And you

know there wasn't any paraffin in the world in those days.

Try dipping a piece of blotting paper in paraffin and in melted butter. You will see that the paraffin is sucked up very much faster. So the flame was small because the oil ran up the wick so slowly. Some way must be devised to force the oil to feed into the wick faster, if it wouldn't go of its own accord.

It was a mathematician, Cardan, who lived fifty years later than Leonardo da Vinci, who thought out how to do this. His idea was to put the bowl containing the oil above the burner so that the oil would flow down to the flame by the force of gravity, like water from a water faucet. He then connected this bowl with the burner by a little pipe through which the oil flowed down.

Another inventor, Karsel, had the idea of using a pump to force the oil into the burner. He



Karsel Lamps are Still Used in Lighthouses

devised an elaborate mechanical apparatus, a pump run by clockwork, which forced the oil into the burner. Karsel lamps of huge size are still used in lighthouses, because they give a very steady light.

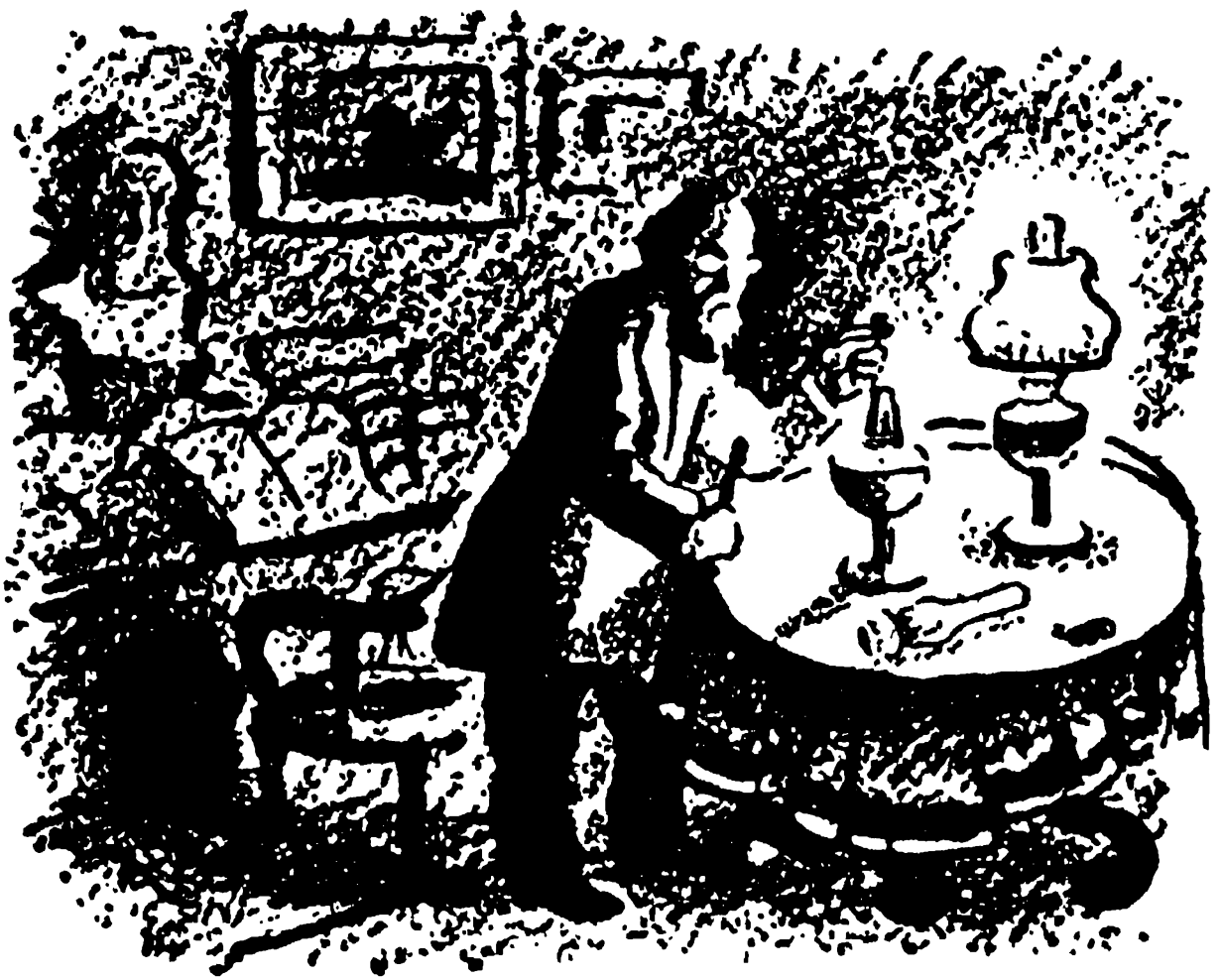
Finally there was a third inventor who put a ring and a spring into the lamp bowl. The spring pressed on the ring and the ring pressed on the oil and forced it to rise up through a pipe into the burner. Such lamps were in use up till a very short time ago; our grandfathers and grandmothers used them.

The Argand Lamp

However, none of these elaborate lamps burned so well as our present-day paraffin ones, although they were so much more complicated. The trouble

was that the wicks weren't good. They still used twisted wicks like those in tallow candles. And these wicks had the same kind of flame, too, as the candle, only it was larger. No wonder these lamps smoked. No air could reach the centre of the flame.

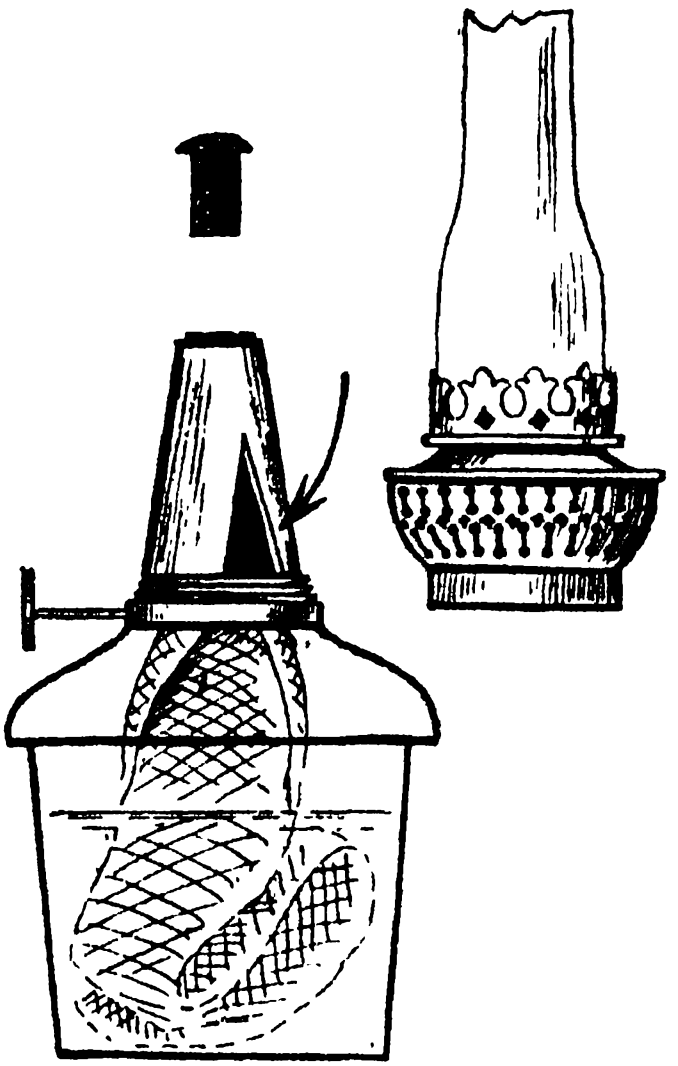
A Frenchman, Leziere, figured out that a wick could be made flat like a ribbon, instead of being round like a cord, like the wicks in our little kitchen lamps. This gave a flat flame and the air could reach all parts of it more easily. Then Argand, the man who had thought out the idea of putting a glass chimney on the lamp, invented the very best kind of wick. His method was simple. He took a flat wick and rolled it into a cylinder. Then he made a burner in such a way that air could get at the flame from both the inside and the outside. This Argand burner is still used in our big paraffin lamps. Try taking one of these burners apart and



Try taking one of these burners apart

The Argand Lamp

you will see a little crown with perforations in it to admit the air on top of a metal tube round which the wick is placed. This tube is full of



holes through which the air gets to the inside of the wick, and thus reaches the centre of the flame.

People were enthusiastic over this Argand lamp. But it had its enemies, too. One old authoress,

Countess de Genlis, said that "since lamps came into style all the young people have begun to wear glasses. Only older people who read and write by candle light have good eyes."

Of course this is not true. The Argand lamp wasn't in the least bad for the eyes.

The First Street Lamps

During these several centuries which separate the teapot lamp from the Argand burner, great changes had taken place in the streets of cities.

Paris was the first city to have lighted streets. It started by the police requiring every householder to keep a lamp burning in a street window from nine o'clock in the evening on through the night.

Soon regular companies of torch- and lantern-bearers began to offer their services to anyone who wished to hire them. And a few years later the first street lamps appeared in Paris.

This was a great event. King Louis the Fourteenth ordered a medal to be struck to commemorate the occasion. Tourists used to tell the most enthusiastic stories about the impression which the brilliantly lighted streets of Paris made on them. They say that the reign of Louis the Fourteenth is called the "brilliant" because of these street lamps.

It is interesting to read the memoirs of people of those times. I have before me a book, with a long title, after the fashion of those times:

A VISIT TO PARIS

DIRECTIONS INTENDED FOR THE USE OF TRAVELLING GENTLEFOLK TO ADVISE THEM WHAT TO DO IF THEY WISH TO MAKE THE BEST USE OF THEIR TIME AND MONEY WHILE STAYING IN PARIS.

WRITTEN BY THE COUNSELLOR TO HIS HIGHNESS PRINCE WALDECK JOACHIM CHRISTOPH NEMEITZ,

PARIS, 1718.

We read on one of the pages of this book :

" One may safely be out on the main streets up to 10 or 11 o'clock at night. At nightfall street lamps are lighted on all streets and bridges. These burn until two or three o'clock in the morning. These lamps are suspended on chains at regular intervals along the middle of the street. They make a very beautiful sight, especially when one stands at an intersection and looks down the different streets.

" Some shops, cafés, taverns, and tobacco shops remain open until ten or eleven o'clock at night. Their windows are illuminated with an enormous number of candles which cast a brilliant light on the street. In fine weather there are as many people on the streets at night as in the daytime. Thefts and murders are of rare occurrence on these crowded lively streets. But I would not guarantee that you might not be robbed on the little streets.

Paris in 1718

I do not advise anyone to go about the city on a dark night. For, although there are mounted watchmen on guard throughout the city, nevertheless things happen which they do not see.

"Not long ago the carriage of the Duke of Richmond was stopped at midnight by unknown persons not far from the New Bridge. One of the group forced himself into the carriage and ran the duke through with his sword.

"After ten or eleven o'clock at night it is impossible to find a porte-chaise or a fiacre for hire. The best thing is to take a servant along to walk ahead with a torch."

In 1765, Paris installed a new kind of street lamp, "reflector" lamps, using oil lamps instead of candles, with bright reflector-plates. Some kerosene lamps are still made with these reflectors. This new kind of street lamp was in use for many years. One of them, at the corner of Vanner

Street and Place de la Grève, became famous during the great revolution, for on it the revolutionary citizens of Paris hanged royal officials and courtiers. Once a certain abbot, who was being dragged to the lamp-post to be hanged, saved his life by shouting: "Very well, hang me then, but will that make your light any brighter?"

London was lighted up twenty years later than Paris. One inventive man named Edward Hemming agreed, for a small sum, to place a street lamp at every tenth door. True, he didn't need to have them there all the time, only on moonless nights; and not all the year round, only in winter; and not all night, but only from six o'clock to midnight. But nevertheless his proposal was received with the greatest enthusiasm. They hailed him as an inventive genius; said that "the inventions of all other inventors were nothing in comparison with the achievement of this man who had turned night into day!"

" The watchman, covering his head with a piece of matting, scrambles up the ladder to light the street lamp "

Here in Russia as recently as a hundred years ago our streets were still lighted with oil lamps. Gogol has left a description in his story, " Nevski Prospekt ", of how the streets of Petersburg looked in those days :

" As soon as dusk falls on the houses and streets, and the watchman, covering his head with a piece of matting, scrambles up the ladder to light the street lamp, Nevski Prospekt begins to stir with life and motion. . . . This is that mysterious hour when the lamps give their weird and fascinating light. . . . Long black shadows glide along the walls and pavements, their heads reaching almost to Police Bridge. But keep away from the street lamps, for God's sake ! Hurry by them as fast as you can ! You're lucky if you get off with no more than an evil smelling grease spot on your dress coat."

GAS AND PARAFFIN LIGHTS

GAS AND PARAFFIN LIGHTS

A Gas Factory in a Candlestick

IT wasn't very cheerful a hundred years ago to spend the evening by the dim light of tallow candles or oil lamps. It was hard to read, almost impossible if the print was fine.

When the lamp was lighted it would burn for a time but in about half an hour it would begin to die down. The heavy rape oil didn't feed well. The wick would get charred at the ends. The lamp had to be relit about every two hours.

People began to think about getting something else in the place of oil. And, sure enough, a new fuel made its appearance. Long years ago the "kindle-light" had been replaced by oil, now this oil was replaced by a gas, illuminating gas. How could they burn gas in a lamp and where did they get it?

If you put out a candle you will see a white smoke rising from the wick. You can light this smoke with a match. The flame of the burning smoke jumps from the match to the wick and the candle lights up again.

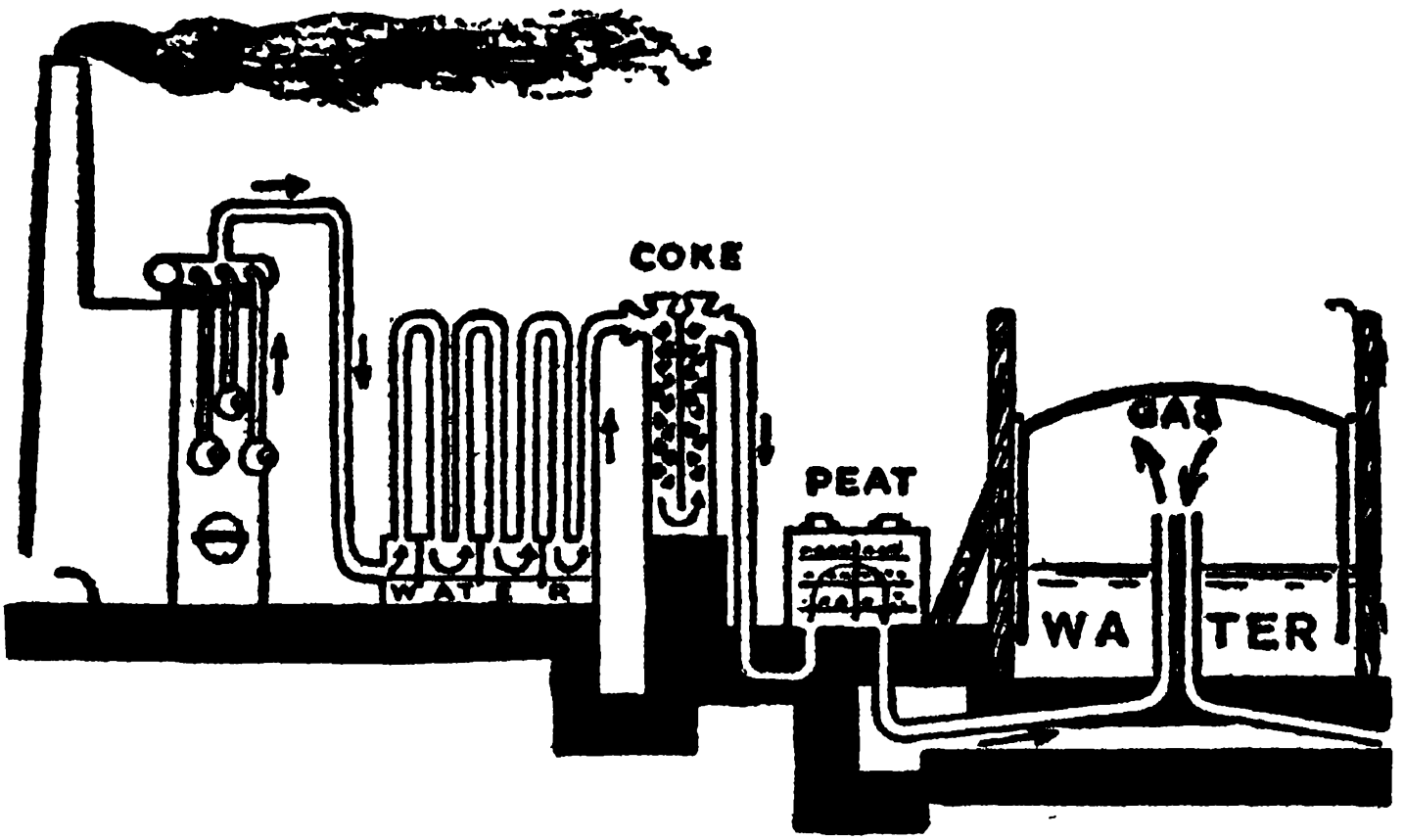
A candle is a little gas factory. When stearine or tallow is burned it first melts, then turns into gas and water vapour, which is what we see when we put the candle out. Burning gas and vapour, that is what a flame is. The same thing happens in a lamp, too. The oil or paraffin is turned into gas and water vapour which burn, thus making the flame.

The First Gas Works

Someone conceived the idea that combustible gas could be obtained in a gas plant instead of in a lamp, and that from this gas plant it could be

piped to burners in different places. But instead of tallow or oil he used coal, which is cheaper.

This man's name was William Murdock. He is



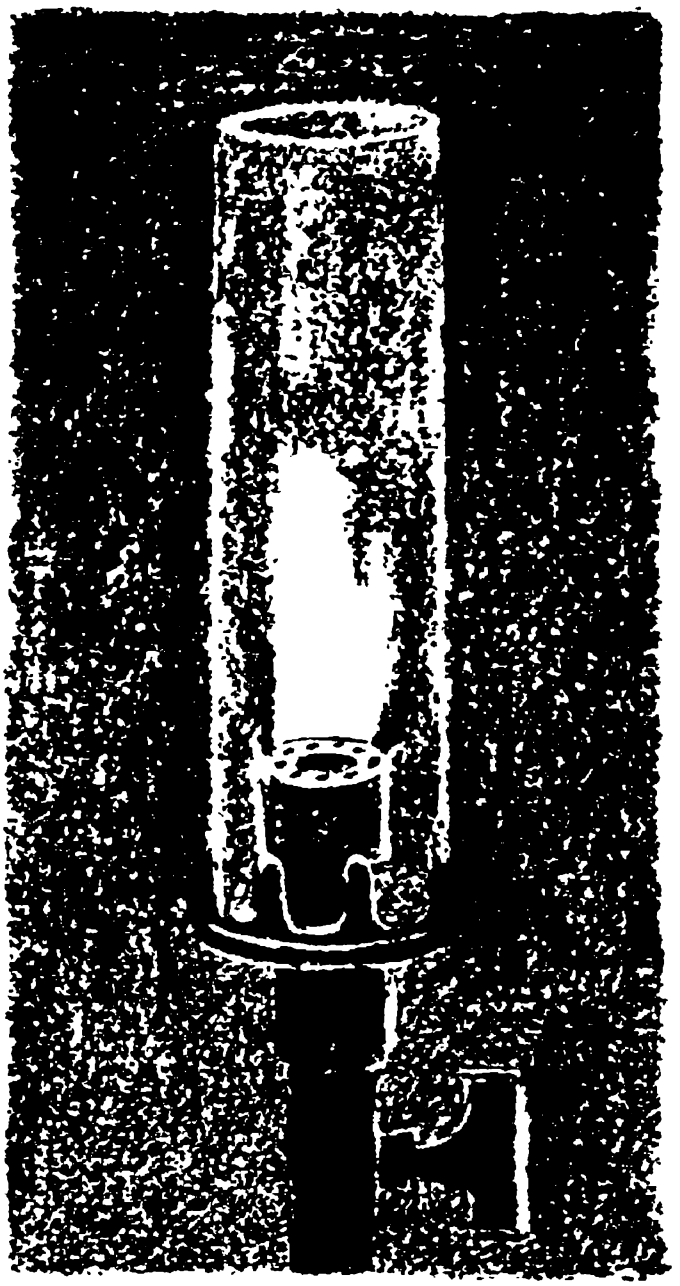
Elevation of Gas Works

the same Murdock who built the first steam engine in England. Murdock was a working man at first, and later an engineer in the factory belonging to Boulton and Watt. This was the first locomotive works.

In this famous factory Murdock built his gas plant, and it was not an easy thing to do. He knew that in order to get a combustible gas he had to heat his coal white hot. But if coal is white hot it will burn up and there will be no gas. How could he get out of this dilemma?

Murdock's solution was a simple one: instead of heating the coal in an open furnace he used a closed one, a "retort", into which no air could penetrate. Combustible gas does not burn without air and it could thus be piped to any place desired.

But there was still another difficulty. Gas isn't the only thing obtained from coal when it is burned. There are also soot and water vapour. As the gas comes out of the retort it cools and these vapours liquefy. Now, if the gas were allowed to pass through the pipes in this form these liquids would quickly settle in them and clog them up. To prevent this the soot and water are very carefully



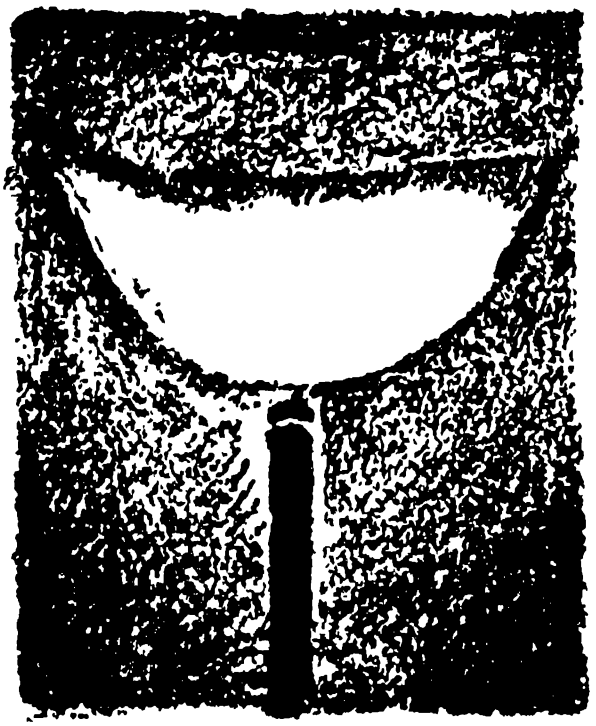
Argand Burner

separated out at the plant. The gas is cooled by passing it through a series of perpendicular pipes, cooled on the outside by air or water. In this cooler the water vapour and soot condense and settle to the bottom, the gas goes on through the pipes to the burners.

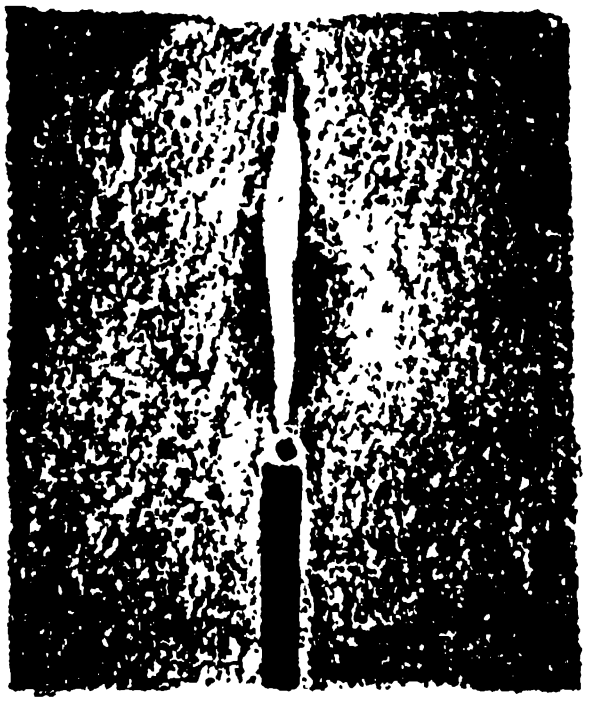
At the same time that Murdock was carrying on his experiments with gas lighting a Frenchman named Lebon was doing the same thing. In 1811, in a journal entitled *Magazine of All the Newest Inventions, Discoveries and Improvements*, there appears the following notice:

" M. Lebon has shown that a pleasant heat and a very brilliant light can be obtained by carefully collecting smoke and burning it. The inventor gave a demonstration of his invention and seven rooms and a garden were successfully lighted up with this new lamp. The inventor calls his apparatus a ' thermo-lamp ', that is a ' heat light.' "

It wasn't nearly so hard to think out a good gas burner as it had been to think out a lamp. All that was necessary was to put a little cap on the end



Perforated Gas Burner



A Simple Gas Burner

of the gas pipe, with a slit in it to let the gas out, and it gave a brilliant flame. Later the principle of the Argand lamp was used here too. In the Argand gas burner there are many little openings arranged in a circle, to permit the air to reach the

centre of the burner. And, as in a paraffin lamp, a glass chimney is placed over the burner.

At the time of the appearance of gas light, oil lamps had reached such a state of perfection that all the inventors of gas burners had to do was to adapt them to the new uses.

Gas made as much of an impression on people in those days as the invention of radio and aeroplane did in our day. It was the talk of the time. They wrote in the newspapers : " Day and night one can keep a fire burning in the room without having to give it the least attention. It can be suspended from the ceiling and lights up the whole room and doesn't have to have a candlestick to cast a big shadow, and it doesn't smoke at all."

In the humorous periodicals of the day one finds many verses, cartoons, and caricatures about gas lighting. In one of these caricatures there is a fashionable lady with a dirty beggar woman standing

beside her. In place of a head, the lady has on her shoulders a brilliant gas light—the beggar woman has an oil lamp. In another picture there is a gas lamp dancing about on slender legs near an ugly spluttering tallow candle. Under this candle, as if under a tree, there are two figures seated: an old man with a book in his hand and an old lady knitting a sock. They are evidently making a great effort to do their work by the dim candle light. Melted tallow is dripping down on their heads.

Now all large cities have gas works. The gas is taken along the streets through underground pipes, like water pipes. The only difference is that a water tank is always placed as high up as possible so that the water will have pressure enough to reach the upper stories of the houses; while the gas plants are always built in the lowest part of the city. Gas is very light and goes up more easily than it goes down.

Illumination by Gas

Illumination is not the only thing for which gas is used. Gas stoves are in common use both in foreign countries and here (in Russia).

A Swell, a Shoemaker, and a Lackey

For some time after gas lamps were burned in the streets, houses were still as dark as ever. It was too expensive to light houses with gas. And the oil lamps and tallow candles burned wretchedly. They say that the writer Belinski used to have an oil lamp standing on his work-table but that he never lighted it, because he couldn't bear the smell of the burning oil. He always worked by the light of two candles.

The problem of some better fuel for illumination was still unsolved. But instead of looking for something new they tried to improve what they had.

They found out that, in place of the soft, greasy tallow candles, they could make nice hard candles, candles that wouldn't soil one's hands, wouldn't sputter when they burned, and wouldn't smoke. All that was necessary was to purify the tallow, or rather to separate out its best and firmest part, stearine.

Tallow consists of several things: glycerine and fatty acids. And the fatty acids are not all the same! Some of them are hard, this is *stearine.* Some of them are soft, this is *olein.* To extract the stearine from the tallow one must first of all get out the glycerine. To do this the tallow is boiled in water and sulphuric acid. The fatty acids float to the top, leaving the glycerine at the bottom. The stearine is then squeezed out from the olein in presses. Hard cakes of stearine are obtained, and this is melted and moulded into candles.

Stearine candles were invented in France. Soon

stearine factories sprang up all over Europe. Here in Russia a stearine factory was started in St. Petersburg, the Nevski Stearine Works. It is still in operation.

People were delighted with the new candles. And no wonder. Just compare them with the old tallow and wax candles. Hear what V. L. Petrovski, brother of the famous revolutionist, Sophie Perovskaya, has to say about the new stearine candles :

" In those days rooms were lighted in the evening by tallow candles. Even on card-tables lights of this kind were placed. To snuff off the charred ends of the wicks there were special snuffers, lying on a tray. Often the snuffers and the tray were both of silver. We also sat and worked in our rooms by such lights.

" Once my father went to Petersburg on official business and brought home with him a novelty, a

whole box of stearine candles. On our next holiday, the fourth of December, mother's name-day, we gave a ball. The dancing-hall and all the other rooms were lighted by these stearine candles, placed in candelabra and wall brackets. The effect was tremendous and our party was crowded with people eager to see the new kind of illumination."

There is a picture on an old magazine representing two stearine candles as an elegantly dressed couple, standing proudly in the centre of the scene. with big candles on their heads. At the right stands an untidy-looking shoemaker with a tallow candle on his head. The tallow is dripping on his ragged clothes and hanging like icicles from his nose. At the left is a liveried servant with a wax candle. Both the wax and the tallow candles are smoking horribly, while the stearine ones are burning bright and clear.

To understand this picture you have to remember that in those days servants and shoemakers were considered of much less importance than any silly fop.

An Easy Riddle

So the problem of the candle was finally settled satisfactorily, but lamps were as bad as ever. No matter how many clever devices they thought out, no matter how many springs and pumps were added, lamps continued to burn wretchedly. And no wonder, for no matter how much the lamp burner was improved it wouldn't help—because the trouble was not in the burner but in the fuel. As soon as people learned how to get paraffin from petroleum—this was in the middle of the last century—all their difficulties vanished.

All their ingenuity had been wasted in trying to devise some way of making a fuel burn well which by its very nature burned badly. It's quite another story with paraffin. It runs up into the wick much more easily than oil. So the inventor of the paraffin lamp, an American named Silliman, didn't have to think of anything new. All he had to do was to discard all the unnecessary parts of the old lamp, the pumps and springs, all the contraptions that had been used to force the oil into the wick.

That's the way it often is: people puzzle and worry and think out all kinds of complicated apparatus, and in the end it turns out that the answer is very simple. All that is necessary is to find the clue. Paraffin was this clue.

A FLAMELESS LAMP

A FLAMELESS LAMP

A Poker and a Lamp

EVERYONE knows that a poker is not a lamp. But a poker can be made to give light. All you have to do is to hold it in the fire for a long time. It keeps getting hotter and hotter until it finally becomes a dark red colour.

Keep on holding it in the fire and it will get cherry red, then bright red, then yellow and finally white.

(You can't heat a poker white hot in an ordinary heating stove. To do that you must have an intense heat, one that cannot be measured by the ordinary thermometer, 1300° C.)

Take a candle or lamp, any kind of lamp, electric, gas, paraffin, or any other kind, they all

give light for the same reason that the poker does —because they are raised to a very high temperature, are incandescent. In the flame of the candle and the lamp there are tiny particles of incandescent carbon, floating like the dust motes in a ray of sunlight. We don't see them ordinarily. They are visible only when the lamp smokes. Now, sooty smoke is very disagreeable. But it would be a great misfortune if there were no soot—that is, tiny particles of unburned carbon in the flame. The flame of burning alcohol, for instance, has no soot in it and for that reason gives hardly any light.

So it is incandescent carbon that is doing the work. But carbon can be heated white hot without fire, by means of an electric current, for instance. That's what the inventor of the first electric lamp did, used an electric current in place of fire.

A Flameless Lamp

If you had told a man living a hundred years ago that sometime a lamp would be invented that would give light without fire, he would have thought it absolutely impossible. Yet even at that time the first experiments for obtaining electric light were being carried on in laboratories. As now, perhaps, somewhere in the quiet of a laboratory, an as-yet-unknown inventor is working away on some wonderful discovery that we don't even dream of.

The first flameless lamp was invented by an English chemist, Sir Humphry Davy. It was not an easy thing for him to work on this in those days when so little was known about the electric current and so few knew even that little. There was no such thing as a machine for producing electricity, and no one had ever thought of such a thing as a power station. The current was

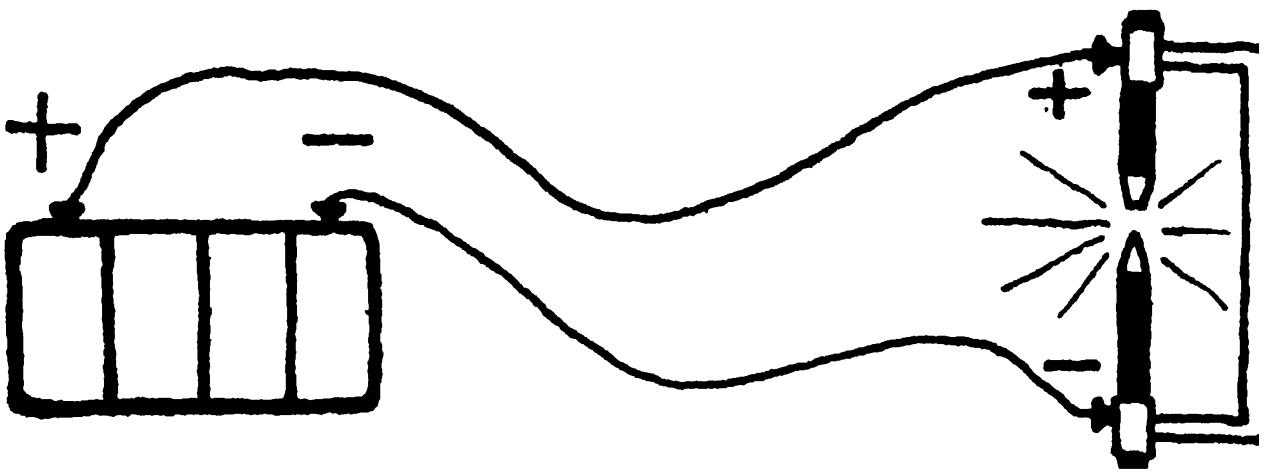
produced only in scientific laboratories by the aid of batteries composed of galvanic cells.

Don't be frightened by this high sounding name. You have undoubtedly seen batteries in a pocket flash-light or in a box in the hall near the electric door bell.

I shall not take the time to explain in detail the construction of this battery. The important thing is that the electric current is produced in the cell and goes from it along a wire to the lamp in the flash-light or to the bell. It then returns to the cell along another wire. The cell is like a pump. Just as a pump sends water along the pipes so the cell sends the electric current along the wire. The terminal through which the current passes out of the cell into the wire is called the positive pole and is designated by the sign +, the one by which the current returns to the cell is called the negative pole and is designated by the sign —.

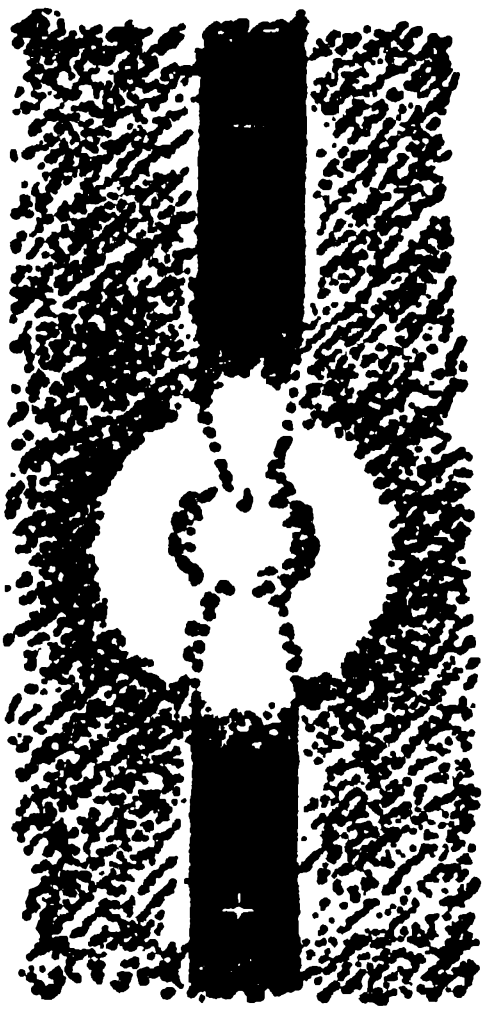
To get a strong current several such electric pumps are united together into a battery of electric (or galvanic, which means the same thing) cells.

That's all there is to it.



Humphry Davy once made the following experiment: he took two little rods of coal and fastened one of them to the positive and one to the negative wire. When he brought the ends of these rods close together the current jumped over the intervening space from one to the other. The ends of the rods were heated white hot and between them appeared an arc of bluish flame.

If we could examine this arc more closely we should see a whole stream of particles of incandescent carbon flowing from the negative to the



positive rod. This makes a protuberance on the positive and a depression on the negative rod. The space between the rods becomes greater all the time, because the coal gradually burns up. To

keep the arc from going out, the rods have to be brought nearer to each other every little while.

This arc is called the "Volta arc" in honour of a scientist named Volta.[1]

Complicated Lamps Return

At first this arc was only an interesting scientific experiment. It was not possible to use it in lighting because the coal burned up too fast. It was about thirty years before a certain scientist, this time a Frenchman instead of an Englishman, used coke in the place of coal. Coke is what is left after the

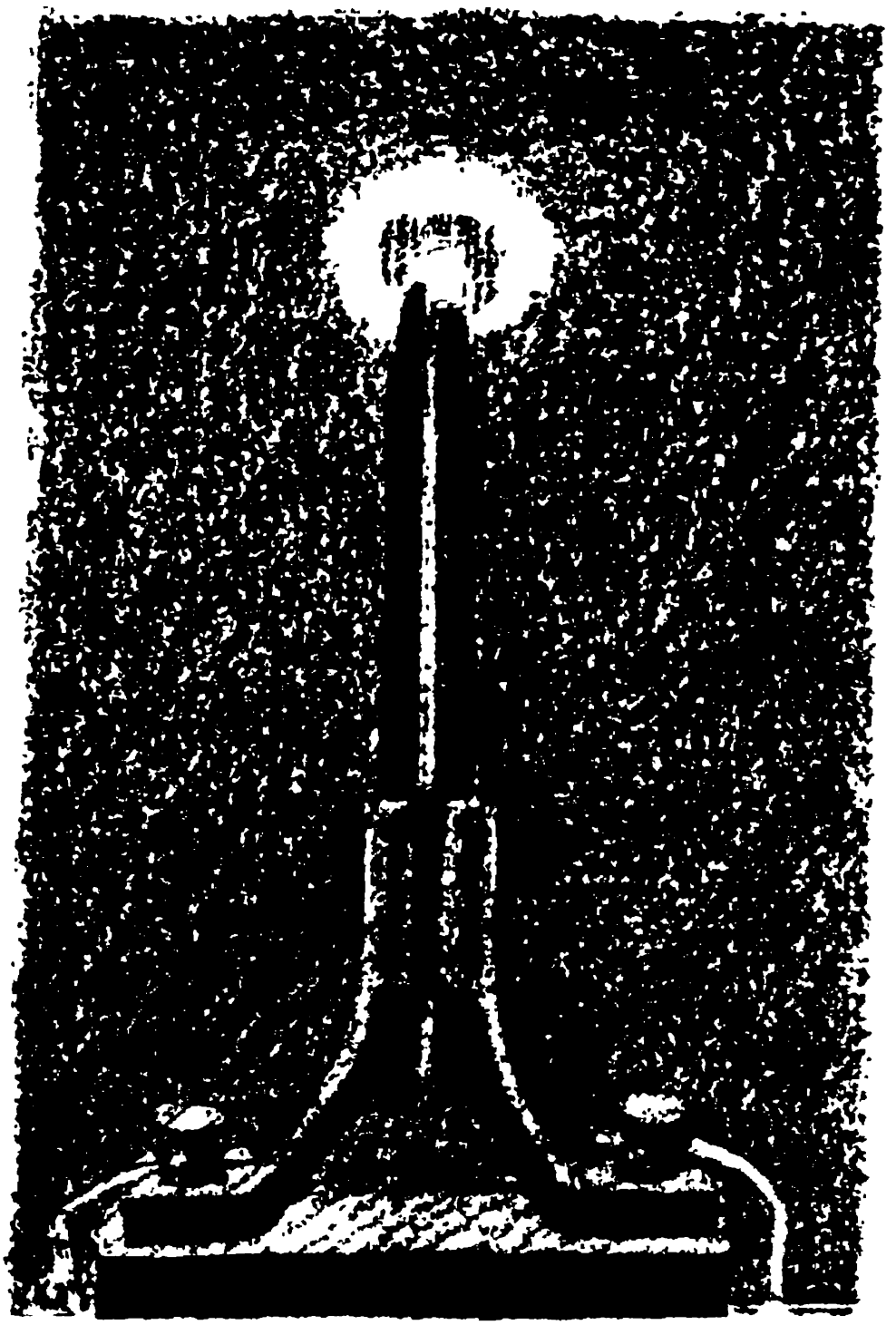
[1] A Russian, Professor Petrov, discovered the volta arc at the same time as Davy. In the arc, just as in the flame of a kerosene lamp or a gas burner, it is incandescent carbon that gives the light. The difference is only that here the heat is supplied by an electric current instead of by fire.

coal has been burned in gas-plants for making illuminating gas.

Now coke burns more slowly. But this was not all that was necessary. Some way must be devised for keeping the rods near enough to each other all the time. So we find clockwork again used in a lamp. This time to keep the ends of the rods equally distant from each other.

They tried lighting the streets of Paris with arc lamps provided with a clock mechanism. One square was lighted up but the mechanism was so costly that it had to be abandoned.

A German Scientist, Gephner Altenek, devised a much cleverer way of keeping these rods near enough together. His arc lamp was so complicated that it would take too long and be too difficult to explain it. The essential thing in it was that he put a magnet in his lamp which (at the necessary time) attracted an iron strip attached to one of the rods.



Yablochkov Candle

The distance between the rods was thus diminished and the lamp continued to work.

As you see, work on the arc lamps was going on in all the countries of Europe. Here in Russia an inventor by the name of Yablochkov was working on them. He figured out that the rods should not be arranged one above the other, but side by side, parallel, as shown in the picture. To keep the distance between them from changing he would pass the current first into one and then into the other side. Thus the rods would be alternately positive and negative and first one then the other would burn up more rapidly. The rods were separated from each other by a strip of gypsum which was gradually volatilized by the intense heat of the candle.

These " candles " of Yablochkov gave a beautiful rosy or violet light. They were greeted with the greatest enthusiasm at an exhibition in Paris.

The Tables Are Turned

There was a time when people racked their brains over the problem of getting lamps to give a brighter light. And now, several hundred years later, we find scientists doing precisely the opposite. The trouble was that these arc lamps were too bright. You can't put a six hundred candle-power lamp on your writing desk. It might put your eyes out and how expensive it would be!

Some way must be found to make the light of the electric lamp less brilliant. So they figured out that it would be simpler to bring the carbon itself to an incandescent heat by means of the electric current, doing away with the arc entirely.

If an electric current is sent through a slender carbon filament, the carbon becomes heated. When the temperature reaches 550° C. it begins to give

off light. This light is at first red, then it glows whiter and whiter, until finally when a very high temperature is reached it is entirely white. In a word, the same thing occurs as when we heated our poker in the stove.

So they began trying to send the current through the carbon filament. But the filament burned up at once and the lamp went out. To prevent this it was necessary either to exhaust the air or to fill the lamp with some gas which would not support combustion, for example, nitrogen.

Paraffin and oil lamps need air, just as a person does. Without air there cannot be a flame. But here it is just the opposite—air does harm because no flame or combustion is desired. For, you see, the filament is heated by the electric current, not by a flame.

The first good lamp using a carbon filament was invented fifty years ago by the famous American

inventor, Thomas Alva Edison. He used a carbonized bamboo filament. To keep this filament from being burned up, Edison very carefully exhausted all the air from the lamp.

The little glass tip which we used to see on electric light bulbs is the remnant of a glass tube through which the air was been exhausted by a pump. When the air is all exhausted a hot flame is applied to the tube which breaks off. The little end left sticking to the bulb is sealed up. In this way Edison succeeded in producing a lamp which would burn for 800 hours without interruption.

The steamship *Columbia* was the first to use these carbon lamps of 20 candle-power for illumination. And very soon the first consignment of electric light bulbs arrived in Europe, consisting of 1800 lamps.

War Between Gas and Electricity

When electric lamps appeared everyone said that this was the end of gas, not to mention paraffin. You see, electricity doesn't smoke or vitiate the air, and it gives a clear white light. And if the wiring is properly done there is no danger of fire. And most important of all, it is generally cheaper than gas.

The people who stood to lose money by the closing of gas- or paraffin-plants began to try to find some way out, began to think how their lamps could be improved so as to hold their own against electricity.

They began to fight electricity with its own weapon. The carbon filament in the electric lamp burns so brightly because it is raised to an intense heat. That is, it is all a matter of incandescence.

So the supporters of gas and paraffin devised a little sieve, made of a material which has a very high melting point, to place over the flame. This sieve was heated white hot and then it gave a clear white light. These sieves were called "Welsbach mantles" after their inventor, Auer von Welsbach.

For several years victory was on their side. Gas light was now twice as cheap as it had been before, because the gas-burners now gave much more light than formerly. And one lamp would do the work previously done by two. So the cost of gas was reduced.

But the supporters of electricity weren't asleep all this time. They made up their minds that they must get a still brighter and therefore cheaper light. There was only one way to do this—heat the filament still hotter. For you know the higher the temperature the brighter and whiter the light. Remember our poker!

The first good electric lamp was invented by Edison

But there was a little hitch here. If the carbon filament is heated too hot it turns to vapour, "burns out" as we say. Something must be found to take the place of carbon.

So they borrowed something from the gas side. In the new gas burners, the light didn't come from incandescent carbon as in the earlier burners, but from the Welsbach mantle, made of a non-inflammable material with a very high melting point.

Why not use a filament made of some such non-inflammable, non-fusible material in electric light bulbs instead of the carbon filament?

They first tried making this filament of osmium. Osmium has a very high melting point but the osmium filaments were not sufficiently strong. Another metal was tried, tantalum; and finally tungsten. Tungsten has the highest melting point

of all metals, 3390° C. This is the electric light still in general use.

It is a curious thing that every new lamp took whatever was best from its rivals, the older lamps. Gas and paraffin lamps took over the Argand burner from the oil lamp. The carbon electric lamps took over the idea of incandescent carbon from the gas and paraffin lamps. Then the gas lamp discarded the carbon and used the Welsbach mantle. The electric lamp, too, discarded the carbon filament and the economical lamp with a metal filament appeared.

So one inventor continued the work begun by another and all worked together for a common end.

The whole history of lighting is expressed in the present prices of gas, paraffin, and electricity. The most expensive of all is the old-fashioned gas burner. The later round burners are a little cheaper. Lighting with a paraffin lamp costs only

Welsbach Mantle

half as much. But the cheapest of all are the latest types of electric, incandescent gas, and incandescent paraffin lamps.

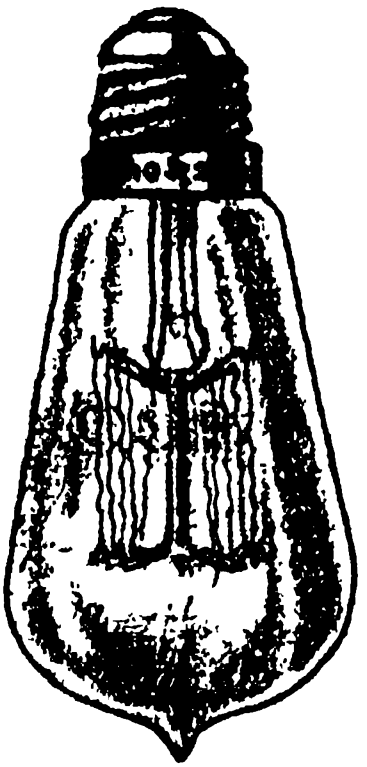
The struggle between gas and electricity is not decided yet. It is difficult to say which will come off the victor.

Which is better, gas or electricity ?

Gas is no more expensive than electricity and it gives a clear white light. It is also easy to light. One doesn't have to climb up to the ceiling on a ladder and light it with a match. There are now gas burners which are lighted by means of electricity. (Even here we can't get along without electricity !) Gas may be used not only for light but for heating and cooking also. Excellent gas ranges are in very common use everywhere, also heating stoves and water heaters.

There are also electric cooking stoves, and electric saucepans, tea-kettles and frying pans.

Electricity is better than gas in many respects. If there happens to be a leak in the gas-pipe the gas leaks out into the room and may poison every-



Electric Lamp

one in it. It may cause a still greater disaster. If much gas leaks out it mixes with the air and forms an explosive mixture. Then if someone happens to strike a match the whole house is blown up.

If electricity is used for lighting there will be no danger of asphyxiation or explosions.

And even when there is nothing wrong with the gas-pipes, gas vitiates the air in a room. Not only gas does this, any kind of lamp in which combustion takes place will do it. For you remember that air is necessary for combustion. Fresh air goes into the lamp and comes out vitiated, no longer good for burning. The same thing happens when we breathe; we take in fresh air and breathe out bad air. A 25-candle power paraffin lamp uses up about 55 pounds of air in the evening. A person breathes only about 7 pounds in the same length of time. That is, one such lamp in a room is equivalent to eight persons.

You can see from this that the more people there are in a room the harder it is to breathe, because the fresh air gets less and less.

Electricity is entirely different. Although from force of habit we say that an electric lamp " burns ", in reality there is no combustion taking place in it. Therefore it cannot vitiate the air.

Electricity has another big advantage: the current can be taken a long way—hundreds and hundreds of miles. One big electric power-station can light up a whole countryside. No wonder that nowadays electricity is being used everywhere, even in the most remote villages which were only recently using the old kindle-light.

An Electric Lamp Which Had to Be Lighted

Before an economical electrical lamp had been invented, a certain scientist, Nernst, invented a very curious type of lamp. In place of carbon he used not a metal filament, but a rod made of magnesium. Magnesium is a substance which does not burn, that is, it is not affected by air. This was precisely what was needed. But the great drawback was that magnesium is a conductor of electricity only when it is hot. So these first

Nernst lamps had to be started with a lighter, like a paraffin lamp. Later Nernst improved on this method of lighting his lamp. But these Nernst lamps are very rarely used. They are too expensive.

The Biggest Lamp in the World

Not long ago a German scientist, Beck, built an electric lamp arc of 2,000,000,000 candle power. At a height of 20 miles above the earth this lamp would give a light equal to that of the full moon. Even at the same distance from us as the moon it would appear to us like a star visible to the naked eye.

The carbon rods in this lamp are heated to 7500°C, that is, hotter than the sun, whose temperature is calculated to be about 6000°C.

This lamp is two yards in diameter.

LIGHT WITHOUT HEAT

LIGHT WITHOUT HEAT

The Struggle with Heat

IN olden times people used the same fire as a heating-stove, a cooking-stove and a lamp. This was, of course, inconvenient and expensive. Suppose you want light. Very well, you may have it. But in order to have light you must sit in a slightly heated room even though it is mid-summer. And what a lot of wood you will have to burn up if you light your house in this way!

People are always looking for something new and better. For many thousands of years they got along with the inconveniences of the open fire, never realizing that it was possible to separate light from heat, the lamp from the stove.

Later, when they wanted only light, they began to burn a piece of kindling wood instead of starting

a fire on the hearth. This kindle-light gave less heat than the fireplace but it was still too hot.

It wasn't so simple a matter to separate light from heat. People worked at it for many hundreds of years and are still working at it. Our electric lamp, like the simple, primitive kindle-light, gives out heat as well as light. True, an electric lamp doesn't heat the room to any great extent. But just put your hand on it and you will see that it is very hot.

Why is it that we have never succeeded in separating light from heat? The reason is very simple. We must have incandescence in order to get light. In the electric lamp we heat up a carbon or metal filament, in a gas light a Welsbach mantle, in a paraffin or oil lamp particles of carbon in the flame.

But every incandescent thing, whether the filament in the electric lamp or an ordinary poker,

gives off invisible heat rays as well as visible light rays. To get rid of the unnecessary heat rays we should have to have a veritable revolution in lighting: get our light in some other way than by incandescence.

But, you say, is there really any necessity for trying to get rid of these heat rays? The heat from an electric lamp is scarcely noticeable. It doesn't bother us in the least.

It isn't a question of our comfort or discomfort, but the fact that these heat rays, which are absolutely useless to us, cost too much. If our lamps did not give off any heat rays at all our light would be a hundred times cheaper than it is. Our electric stations would have to burn a hundred times less fuel.

Light costs us a tremendous amount not only because our lamps are poor but also because our present power-stations are very poorly constructed.

In the steam boiler, in the steam-driven machinery, in the dynamos and in the wiring which carries the electric current a tremendous amount of precious energy is lost. A lamp gets only one-fifth part of the energy which is generated in the fuel. And of this fifth only a hundredth part is actually delivered as light. That is, when we spend one hundred pounds for coal we get only four shillings worth of light.

The Best Lamp in the World

There is one lamp which gives off only light rays without any heat rays at all. I am sure you have seen this best-lamp-in-the-world many times in the grass on summer nights. It is the lantern of the glow-worm or firefly.

Isn't it amazing that the little glow-worm gives a light that is not only better than our best lamps but even better than the sun itself.

The sun gives off five times more heat than light rays, but the glow-worm gives off only light rays. Its light is cold. If it were hot, it would burn itself up.

And the glow-worm outdoes the sun in another respect too. Its light is far superior to sunlight. Sunlight, or the light of an electric lamp, seems to us to be a white light. But it is really made up of a mixture of different rays: violet, indigo, blue, green, yellow, orange and red.

Sometimes a sun ray is separated into its different light rays, refracted. You have all seen how it is refracted when it goes through a prism or the edge of a mirror, throwing a multicoloured bar of light on the wall. And the rainbow is also a ray of sunlight which has been broken up into its parts, refracted.

Now all rays are not equally good for the vision. Red light tires the eyes and seems dim to us. That

is why no one works by a red light. The eye is much more sensitive to a green light. That is why shades on workers' lamps are usually made of green.

In incandescence we always get a lot of red rays. When we heated up our poker it first gave off a red light, one by one the other colours were added to it until it finally got white; that is, a mixture of all the colours.

The higher the temperature, the fewer there will be of the unpleasant dim red rays in comparison with the others. Therefore, to make a brighter and more agreeable light, inventors tried to raise the filament in the electric lamp or the Welsbach mantle in the gas lamp to as high a temperature as possible.

The light given by our present economical light-bulb is better than that of a lamp using a carbon filament because the metal filament can be raised

to a higher temperature than the carbon. The carbon lamp gives a better light than the kerosene one, for the same reason. And so on down to the light of the red hot poker.

But even the economical electric light-bulb still gives off a lot of red rays. This is the reason it is injurious to the eyes to work for a long time by electric light.

To get rid of both the heat rays and the red light rays we must get rid of incandescence. The glow-worm gives his light without the least heat. He gives off almost no red rays. That's why his light is so good. The future inventor must learn from this little glow-worm. If he succeeds in learning his secret, our light will be much better and cheaper than it is now.

Some progress has already been made along this line. They have succeeded in getting two substances from the body of the glow-worm: luciferine and

luciferaze, which begin to give off light when they are mixed. Who knows, perhaps in the future we shall be able to get larger and larger quantities of these substances, and then we shall no longer have lamps in our rooms. We shall have artificial glow-worms instead.

From Bonfire to Electric Light Bulb

We have seen how it was not one single individual who worked alone on the invention of our evening lamp. It was many men, in different lands and different ages. You can easily see how impossible it would have been for one man alone to make so many experiments, changing first the fuel, then the construction of the lamp, then the method of obtaining light itself. This required the intelligent work of thousands of minds. One experiment led to another. One invention suggested another. And

all together worked toward a common end. This end was to get a light which would be bright, inexpensive and good for the eyes.

The work began long, long ago. Scientists think that man learned how to start a fire fifty thousand years ago. Fifty thousand years ago these first attempts were made to substitute fire for the sun; a way was found to produce light and heat artificially.

But the history of lighting does not really begin with the bonfire or the hearth fire, but with the "kindle-light", when man first tried to separate light from heat. The method of obtaining light was discovered—combustion. However, the question was to get some kind of combustion which would give a bright and inexpensive light.

So they began to look about for a fuel. In a kindle-light made of pitchy wood the important thing was the pitch. So they discarded the wood

and kept the pitch and the first pitch lamp was lighted. But this pitch burned badly. Then they tried burning tallow, and finally a vegetable oil. Oil does not burn so very well either, but they didn't have a better fuel yet. So they began to try to make a lamp which would make this poor fuel burn better. All kinds of complicated lamps were devised—lamps with pumps, with clock work, with every kind of clever device.

That was as far as they could go. Yet still oil lamps burned unsatisfactorily. They guttered and smoked and went out two or three hours after they were lighted.

Again the search for a better fuel was begun. And they got gas, stearine and paraffin, all of which burn much better than oil or tallow. With these good fuels there was no need for such complicated lamps, so the lamps grew simpler. All those pumps and clock-work were discarded.

But the problem wasn't solved yet. Gas and paraffin both had their shortcomings. They were sooty, they vitiated the air and they were a fire risk. The whole trouble lay in the fact that in order to get light one had to make a fire.

The conquerors of light had a new task—to make a lamp without a flame. Now the flame was used for the purpose of heating. But an electric current could be used for heating as well as a flame. So the whole thing was begun again from the beginning.

A material suitable for being raised to a high degree of heat must be found. First they tried carbon. But carbon wouldn't stand being heated white hot. To get a bright white light they tried heating up metals which have a very high melting point : osmium, tantalum, tungsten.

It is clear that our electric lamp is not the final solution of the problem, which is to obtain light with a minimum loss of energy as heat.

This means we must get rid of high temperatures; get rid of the incandescent filament. We must get light without incandescence. And there are such lamps already in use.

These are long glass tubes filled with a very rarefied gas. When an electric current is passed through the tube the gas begins to glow with a soft pleasant light. There is no filament here at all. It is the gas, not an incandescent filament which is giving off light. Nitrogen gives a golden light, oxygen a rose coloured light, neon a red light. Letters and pictures for illuminations and advertising signs are made of these gas filled tubes.

At night the façades of buildings which in the daytime are most ordinary and uninteresting-looking are quite transformed; their glittering outlines stand out against the night sky like jewelled palaces.

There are marvellous possibilities for the use of this kind of lighting. Houses of the future will be built not of stone and steel and glass only, but of light too. The Palace of the Soviets in Moscow will make use of this kind of lighting. It will sparkle at night with thousands of brilliant lights.

These glowing tubes will have other uses too. Besides lighting and beautifying cities they will be used as fiery signals to boats and aeroplanes; they will direct the courses of trains and automobiles. The red light of the neon tubes penetrates the thickest fogs.

The first light tubes were badly constructed, they used up too much energy. But they are being steadily improved. There are already some which consume less energy for the amount of light given off than do incandescent lamps. These tubes are filled with sodium vapour and give a lemon yellow light. Recently a sodium lamp has been made in

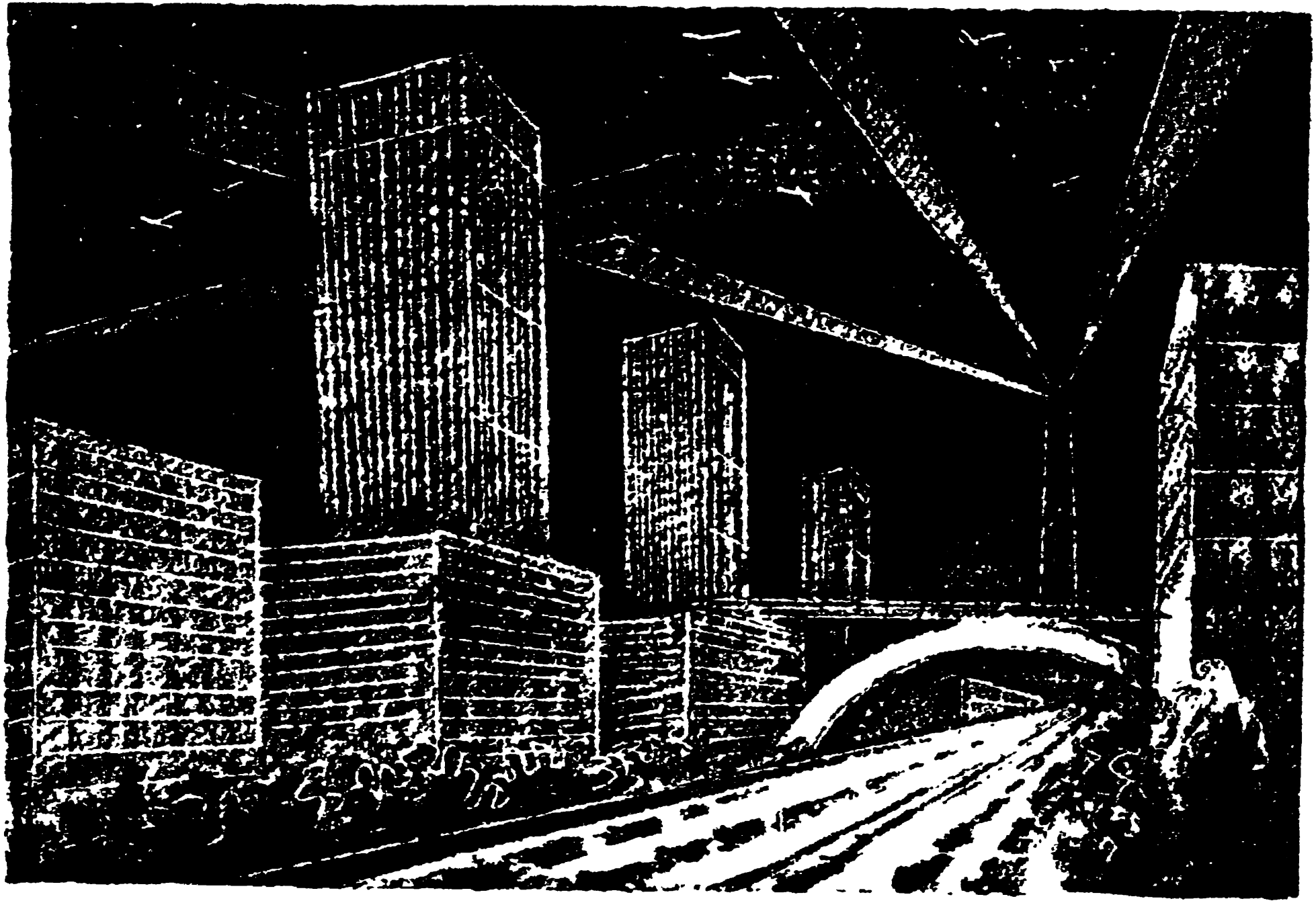
the form of a bulb instead of a tube. This bulb closely resembles an electric light bulb. But the moment you look at it you notice that it has no filament.

A sodium light of 500-candle power uses no more energy than an incandescent light of 100-candle power.

The electric light made of this glowing gas threatens to become a serious competitor of the incandescent light. Such lights are already in use in many places in stores, libraries, hospitals and other public buildings.

In the Croydon aerodrome in England, long tubes are placed in a ditch surrounding the landing field. The ditch is covered with unbreakable glass and at night the landing field seems to be enclosed by strips of light.

Signs can be written on the ground in this way which would be visible to flying aeroplanes.



Electric Light

A hundred years from now it will be hard to recognize our dark, non-luminous planet. Already in America there are long "light corridors" for aeroplanes. In the future the whole earth will be covered with such roads and will shine, not with a reflected light, but with its own light like a new sun!

THE END